

Towards Ubiquitous Computing in Indonesia : Mobile Payment System through NFC Technology

Febriani¹, Dewi Agushinta R.², Isram Rasal³, Hery Herawan⁴, Farhat⁵

^{1,2} Information System, ^{3,4,5} Informatics

Gunadarma University

Jl. Margonda Raya 100 Pondok Cina, Depok 16424, Indonesia

Abstract—Development of mobile devices in Indonesia is growing very rapidly. This rapid development is encouraged by affordable price of mobile devices and increasing number of mobile device users triggered by the presence of new technology offered by various vendors. One of new technologies offered by vendors is NFC technology. Nowadays NFC technology can be found on smartphone which is one of leading vendors in Indonesia. On the other hand, mobile payment development in Indonesia has not grown significantly. The presence of NFC technology can be a stepping stone of mobile payment in the world. It is expected in the future that one mobile device will suffice to perform payment transactions. Payment will not only be possible in one place such as supermarket, but also can be used for payment of train tickets, bus, gas stations and many other places. Thus, the use of NFC technology on mobile devices can unify the various payment systems.

Keywords - mobile phone, NFC, Ubiquitous computing

I. INTRODUCTION

In recent years, smart card technology has been maturing and has been adopted by major sectors such as transport, payment, and retail in advanced countries. At the same time, the mobile phones with internet facilities and multimedia services have successfully become a lifestyle in the society. Now, smart card technology can expand the application domain by adding contactless functionality into mobile phones.

Near Field Communication (NFC) on mobile phone service, which utilizes contactless infrastructure, has recently begun. In some countries, the service utilization of convergence contactless smart card technology and mobile phones has been introduced commercially, and the service is successfully implemented.

In Indonesia, the utilization of smart card technology has just begun. With the growing of mobile market in Indonesia increased to 12 million units in the third quarter in 2011, it was the forerunner of convergence smart cards and Near Field Communication (NFC) [1].

In this paper we will discuss what is ubiquitous computing, smart card, NFC technology, NFC mobile phones, several use cases of NFC mobile phone utilization, global ecosystems of NFC and several challenges of implementation NFC in Indonesia.

A. Ubiquitous Computing

Ubiquitous computing can be defined as the spread of computer use in which the user is located. A number of computers together in an environment are available for everyone who was in that location. Each computer can do the job that not many are prepared to involve human intervention, or even without having to detect where the user is located.

The idea of ubiquitous computing was first presented by Mark Weiser (1998) in the Computer Laboratory of Xerox PARC, which envisions a computer placed in the wall, on the surface of the table, in every object so that one can communicate with hundreds of computers at the same time. Each computer is hidden is placed in the environment and are connected wirelessly [2].

Buxton (1995) said that ubiquitous computing has the main characteristics, they are:

- **Ubiquity:** the interaction is not carried by a channel through a single workstation. Access to a computer can be carried anywhere. For example, in an office, there are dozens of computers, monitors, and so on with a size range from the size of a wristwatch, Pads for notebooks, up to the board for the information boards that are all connected to one network. Wireless networks will be widely available to support mobile access and remote access.
- **Transparency:** the existence of technology that does not disturb the user, not visible and integrated in an ecology that includes offices, housing, supermarkets, etc.

B. Contactless Smart Card

A contactless smart card is any pocket-sized card with embedded integrated circuits that can process and store data, and communicate with a terminal via radio waves. There are two broad categories of contactless smart cards. Memory cards contain non-volatile memory storage components, and perhaps some specific security logic. Contactless smart cards do not contain an ordinary read-only RFID, but they do contain a re-writable smart card microchip that can be transcribed via radio waves.

A contactless smart card is a card in which chip communicates with card reader through an induction technology similar to that of an RFID (at data rates of 106 to 848 Kbit/s). These cards require only close proximity to an antenna to complete a transaction. They are often used when transactions must be processed quickly or hands-free, such as on mass transit systems, where a smart card can be used without even removing it from a wallet.

The standard for contactless smart card communications is ISO/IEC 14443. It defines two types of contactless cards ("A" and "B") and allows for communications at distances up to 10 cm. An alternative standard for contactless smart cards is ISO/IEC 15693, which allows communications at distances up to 50 cm [3].

C. Near Field Communication

NFC is a short-range, standards-based wireless connectivity technology, based on RFID technology that uses magnetic field induction to enable communication between electronic devices in close proximity. It provides a seamless medium for the identification protocols that validate secure data transfer. This enables users to perform intuitive, safe, contactless transactions, access digital content and connect electronic devices simply by touching or bringing devices into close proximity. NFC operates in standard unlicensed 13.56 MHz frequency band over a distance up to around 10 centimeters. Currently it offers data transfer rates of 106 Kbit/s, 212 Kbit/s and 424 Kbit/s, and higher rates are expected in the future [4].

The underlying layers of NFC technology are ISO, ECMA and ETSI standards. Because NFC is compliant with the main international standard for smart card interoperability, ISO 14443, it is compatible with the millions of contactless smart cards and readers already in use worldwide.

In addition, the NFC Forum announced the initial set of four tag formats that all NFC Forum-compliant devices must support. These are based on ISO 14443 Types A and B (the international standards for contactless smart cards) and FeliCa (derived from the ISO 18092). Tags compatible with these mandatory formats are available initially from Innovision, Philips, Sony and other vendors, and more than one billion tags are already deployed globally.

The NFC Forum chose the initial tag formats to cater for the broadest possible range of applications and device capabilities. Types 1 and 2, based on ISO 14443 A, have small memory capacity (1 and 2 kilobytes), which means they are low cost and suitable for single-use applications. They operate at relatively low speed (106 KB/s), and are driven by specific command sets. Type 3 is based on FeliCa, and has larger memory (up to 1 MB) and higher transfer speed (212 KB/s). This means it is suitable for more complex applications, but also more costly. Type 4 is based on ISO 14443 and specifies memory of up to 64 KB, with transfer speeds of between 106 and 424/s – making it suitable for multiple applications.

For two devices which communicate using NFC, one device must have an NFC reader/ writer and the other one must have an NFC tag. The tag is essentially an integrated circuit containing data, connected to an antenna, which can be read and written by the reader.

There are two modes operation covered by the NFC protocol: active and passive. In active mode, both devices generate their own radio field to transmit data. In passive mode, only one device generates a radio field, while the other uses load modulation to transfer data.

The NFC protocol specified that the initiating device is responsible for generating the radio field in this case. The passive mode of communication is very important for battery-powered devices like mobile phones and PDAs that need to prioritize energy use. The NFC protocol enables such devices to be used in power-saving mode, so that energy can be conserved for other operations.

The following chart (Fig. 1) shows how NFC compares in range and speed with other wireless technologies that can be used in a mobile phone. Communication occurs when two NFC-compatible devices are brought within about four centimeters of each other. By design, NFC requires close proximity and it offers instant connectivity, which provides an intuitive consumer experience that can be readily applied to the transit environment.

The real beauty of NFC lies in its role as an enabling technology that opens up various forms of communication and transaction in a very comfortable, user-friendly way. In the same way that people use a straightforward switch on/ off light in the room, or turn a handle to open a door. NFC allows people to use the simple act of touching or placing their device close to something to initiate the desired service. This makes using any form of electronic 'service' and other interactions more accessible to more people, whatever their age or ability [4].

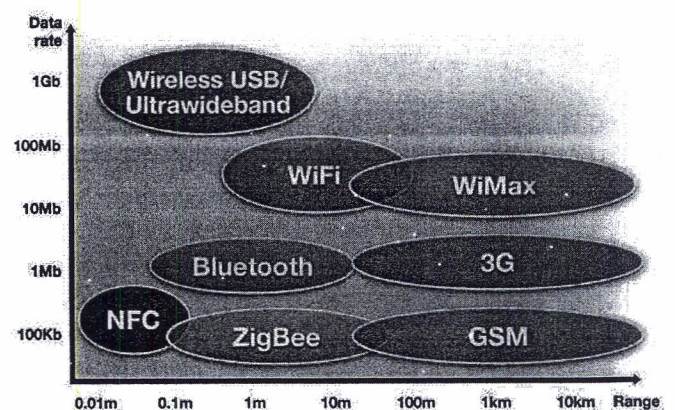


Figure 1. NFC Compared with another Wireless Technology [5]

D. NFC Mobile Phone

When the functions of a contactless card are combined with the wide variety of functions of a mobile phone, the card

evolves into a device whose resulting value is greater than just the value of the two devices added together. This newly defined device is an NFC mobile phone. It is an intelligent mobile network-enabled device that can connect with other NFC devices in close proximity [6].

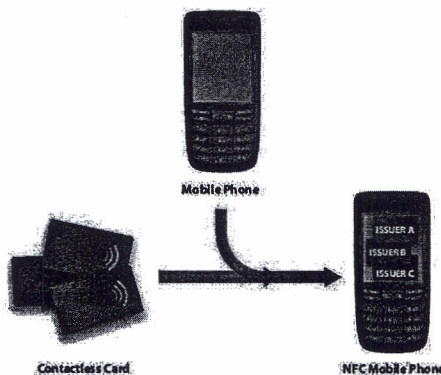


Figure 2. Concept of NFC Mobile Phone [4]

This unique combination of both mobile and NFC technology enables users to enjoy innovative services. Users can access myriad NFC services in their daily lives by having an all-in-one personal device that provides them with a highly personalized and interactive environment.

Three unique advantages of the NFC Mobile Phone will widen the opportunities for NFC services [6]:

- **Interactivity:** The user interface functions of mobile phones – displays, keyboards, touch screens, sounds and vibrations – enable NFC services to be interactive. For example, applications can be provided that display purchase records on the screen. In addition, the card emulation mode is used interactively. For example, a user can check available applications and activate or deactivate an application dynamically through the user interface of a mobile phone.
- **Remote Multi-Application Management:** Multi-application use is supported by the NFC mobile phones. While this may be supported by contactless cards as well, the addition of a mobile network enables application management functions, such as dynamic provision to a trusted execution environment, assignment of trusted areas, application download, personalization and locking/ unlocking. Management functions can be executed remotely in real time, so that a user can start a new service immediately following subscription, bringing new meaning to the term “anytime-anywhere”. Additionally, a user can ask the service provider to stop NFC applications when a device is lost or stolen. Users and service providers are thereby provided with certain controls for managing security and risks associated with their NFC services.

- **Remote User Management:** User management functions are enabled for users and service providers by leveraging the “always on” communication of mobile networks. For example, service providers, with users’ consent, can retrieve NFC service usage records and send users customized information during transactions or on other occasions. In another example, users can access their personal data in real time and can be more proactive about the information they would like to receive.

II. USE CASES OF NFC PHONE UTILIZATION

The following typical day in life of an NFC mobile phone user shows how the device will be integrated into everyday life in the near future [6].

A. A Day in the Life of an NFC Phone User

- Budi gets on a train to go to his campus. (The details are described in section transport).
- He sees a poster announcing a free seminar this evening. He touches his NFC mobile phone to the NFC mark on the poster and transfers the detailed information onto his mobile phone. He reserves seats for the seminar with his mobile phone, using mobile communications (e.g., SMS, internet, packet-based connections), and the complimentary tickets are sent to his mobile phone. He sends a text message to invite to the seminar and dinner to his friend.
- When he arrives at his campus, he touches his NFC mobile phone to the campus gate and opens the door.
- When class starts, he touches his NFC mobile phone to check in attendance.
- At lunch time, he pays for his meal using one of the credit cards stored in his phone (The details are described in Restaurant).
- He meets his friend at 7 PM, and they go to the seminar venue. He touches his NFC mobile phone to a turnstile at the entrance to the seminar, their reservations are confirmed, and they are admitted.
- They visit a shopping center after the seminar, where they go shopping and have dinner (The details are described in Shopping Center).
- When they arrive at their house, he realizes that he has left his NFC mobile phone on the train. He immediately calls the mobile network operator and makes a request to disable all active NFC services in the phone. He can reactivate these services if his NFC phone is later found.

B. Detailed Use Case Description

Transport

1. Assumption

It is assumed that a gate system at the train station has been equipped with NFC readers/ writers, allowing entry only to passengers with legitimate tickets read

from contactless cards or devices. Budi has bought a train ticket that is stored in his contactless card or his NFC mobile phone.

2. NFC Common Service Flow

When Budi arrives at the train station, he enters the gate by touching his contactless card or his NFC mobile phone to the reader/ writer and is granted access. The same action occurs at the destination station in order for him to exit.

3. NFC Phone Service Flow

The NFC mobile phone brings services in addition to those enabled by a contactless card.

- Budi can download and purchase a new ticket using his NFC mobile phone without the need to go to a physical ticket booth.
- While waiting for a train, he can touch his NFC mobile phone to a nearby information kiosk to obtain the latest updated train information and local information such as maps and the weather forecast, and transferred directly to his phone.
- At the same time, additional on-line real-time local traffic information is available to him by linking to a mobile Internet site and/ or by reading "pushed" information.

4. Alternative Service Flow

As some transport systems rely on an honor system and don't have gate systems, Budi can touch his NFC mobile phone to a ticket confirmation machine, thereby activating the ticket and recording the activation time. During his travel, a train conductor may confirm his ticket activation using a portable NFC reader/ writer device.

Restaurant

1. Assumption

It is assumed that restaurants in Budi's campus building accept payments at Point-of-Sale terminals equipped with NFC reader/ writers, and that contactless cards are widely used there. Budi has enabled one or more of his credit/ debit card applications in his NFC phone.

2. NFC Common Service Flow

Budi pays for his lunch at the restaurant by touching his contactless card or his NFC mobile phone to the Point-of-Sale terminal.

3. NFC Phone Service Flow

The NFC phone brings services in addition to those enabled by a contactless card.

- Using his NFC mobile phone, Budi chooses which credit/ debit card application to pay with.
- He can link to a mobile banking site to check the balance of a credit/ debit card prior to making a payment or view his usage/ purchase history.
- He can receive messages indicating that the balance of a credit/ debit card is low or indicating that a payment to a credit card is due.
- Depending on the transaction amount, Budi may be prompted by the NFC mobile phone to authorize the payment. For example, authorizations might range from simple and quick confirmations in the case of lower amounts all the way to special authentication mechanisms such as biometrics for large amounts.

4. Alternative Service Flow

At some point in the future, it may be possible for Budi, as an informal merchant in his spare time, to use his NFC mobile phone as a Point-of-Sale terminal to accept contactless payments from his customers' NFC mobile phones or contactless cards.

Shopping Center

1. Assumption

It is assumed that the growing popularity of NFC mobile phones will provide an incentive to retailers to enhance the functionality of their current Point-of-Sale terminals equipped with NFC readers/ writers so that they can read coupons from NFC mobile phones. It is also assumed that retailers and consumer goods manufacturers will offer a variety of mechanisms to obtain coupons, such as a "push" or "pull" to NFC mobile phones, or reading them from conveniently placed smart posters. With this ubiquity of NFC coupons and opportunities to redeem coupons, it is assumed that Budi has downloaded and personalized the required applications on his NFC mobile phone.

2. NFC Common Service Flow

Entering a shopping center, Budi makes a purchase in a shop and pays by touching his contactless card or NFC mobile phone to a payment terminal.

3. NFC Mobile Phone Service Flow

The NFC mobile phone brings more new services to the retail environment.

- Upon entering the shopping center, Budi touches his NFC mobile phone to a conveniently located kiosk and:
 - Receives shopping center loyalty points for returning to the center

- Receives information linking the current coupons on his NFC mobile phone to stores within the center offering those consumer goods and possibly additional discounts
- Receives special offers customized to his profile directly to his NFC mobile phone
- Walking through the center, Budi notices a smart poster offering him a discount on a product that he has been considering purchasing. Budi touches his NFC mobile phone to the poster to retrieve the coupon.
- Budi chooses some products to buy in a store, and during the checkout process he touches his NFC mobile phone to the Point-of-Sale terminal to:
 - Automatically redeem coupons matched to the items he is purchasing
 - Make the purchase
 - Receive new special offers for future purchases customized to his profile
- Budi can check the history of purchases and remaining loyalty points on his NFC mobile phone whenever he wants.
- Users can share information and coupons, where permitted by the coupon issuer, by touching their NFC mobile phones together.

III. GLOBAL ECOSYSTEMS OF NFC

As shown in the diagram (Fig. 3), the current contactless business domain is expanding into domains including NFC mobile business opportunities. In some mass market businesses such as transport or payment, a contactless infrastructure already exists in a growing number of schemes, and users have some experience with those contactless services. The NFC mobile phone will enhance these existing services and provide opportunities for new revenue sources.

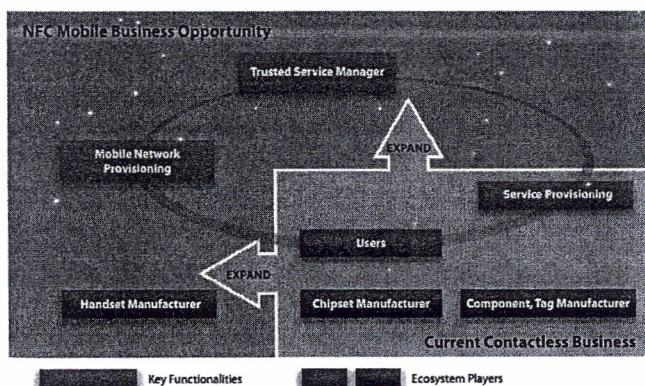


Figure 3. NFC Phone Ecosystems [6]

The NFC mobile ecosystem can be built as a new marketplace, and its success depends on the win-win relationships among all the stakeholders [6].

The NFC mobile ecosystem extends the current contactless ecosystem model with additional functionality. There are multiple possibilities for ecosystem players to provide these mobile system functionalities, which are identified in the following description of key functionalities, they are:

• Service Provisioning

Service Provisioning is a function of the current contactless business enabling users to subscribe to and receive their personalized contactless cards, and this capability will expand for NFC phone services. The functions to which a user subscribes and the functions of the Service Provisioning are preparing the personalization data, will ride upon the existing infrastructure. New functionalities such as remote user management and authentication will then emerge due to the availability of a connected network.

• Mobile Network Provisioning

Mobile Network Provisioning, while existing in the mobile domain, adds new functionality to the contactless domain to realize the NFC phone ecosystem. It includes functionalities to maintain the network infrastructure, to provide data connectivity service to users, to offer user authentication for ensuring that only contracted users can connect to the mobile network, and to offer user care for the data connectivity service. This key functionality is usually performed by the Mobile Network Operators (MNOs) or Mobile Virtual Network Operators (MVNOs).

• Trusted Service Manager

The Trusted Service Manager (TSM) provides a contact point between service providers and NFC mobile phones. SPs can provide NFC mobile phones with remote multi-application management functionality through the TSM.

This new functionality includes the following:

- Issuing and managing a trusted execution environment
- Assigning trusted areas within a trusted execution environment to a specific service
- Managing keys for a trusted execution environment
- Securely downloading applications to NFC mobile phones
- Personalizing applications
- Locking, unlocking and deleting applications according to requests from a user or a service provider

These functionalities can be performed by mobile network operators, service providers or third parties, and all or part can be delegated by one party to another.

There are some ecosystem players, they are:

- **Users**

An NFC mobile service user is required to have an agreement with the service provider of an NFC phone service prior to its first use. In addition, the user is required to subscribe to mobile network provisioning service and have an NFC phone in order to make use of NFC phone services.

In the era of the plastic card, users typically need to have a different contactless card for each service, but when the NFC phone becomes available, they can put all their services on one mobile device.

- **Chipset Manufacturers**

Chipset manufacturers provide the integrated circuit components (ICs) needed for all NFC devices, in line with the relevant technical standards (ISO/ IEC, ECMA, ETSI, and NFC Forum). Chipset development is carried out in close cooperation with handset manufacturers and service providers in order to fulfill application requirements.

- **NFC Handset Manufacturers**

Handset manufacturers design and produce NFC phones according to industry standards. They provide capabilities for service providers to develop applications that provide an intuitive experience to users. Handset manufacturers compete by providing attractive combinations of design, price and feature sets, where NFC capabilities make applications and service offerings easier to use, and also by enabling new usage scenarios for phones.

The integration of cutting-edge technologies and services in mobile phones will contribute to a flow of innovations and acceptance that encourages users to adopt NFC services and also to upgrade their current mobile devices to NFC phones offering these services.

- **NFC Component and Tag Manufacturers**

NFC component and tag manufacturers design and produce devices according to requirements from service providers and industry standards. They also deliver the following values to the ecosystem in order to reduce the implementation efforts of service providers.

IV. CHALLENGES OF IMPLEMENTATION NFC IN INDONESIA

Some sectors seem to have adopted contactless smart card, in transportation section such as Transjakarta Busway Management in collaboration with DKI Bank issued "JakCard" for the payment of the use of Transjakarta bus

services. PT Kereta Api Indonesia (Limited) and PT KAI Commuter Jabodetabek published "Commet" for the payment of the use of commuter rail service line Jabodetabek. PT. Jasa Marga, PT. Mandalasakti Marga, PT. Citra Marga Nusaphala Persada and PT. Jakarta Outer Ring Road in cooperation with Mandiri Bank issued "E-Toll Card Self" for the payment of the toll road service.

In retail section, PT Indomarco Prismaatama in cooperation with Mandiri Bank issued "Indomaret Card" for payment in Indomaret store.

Further, Indonesia uses RFID ISO-14443, one of RFID technology, with the frequency 13.56 MHz, in implementing this ubiquitous computing technology. Unfortunately, it is still illegal application because there is no regulation from Indonesia government and still being study by DIRJEN POSTEL Indonesia. But later, this technology will replace barcode technology because it has more advantages than barcode technology [7].

V. CONCLUSION

The presence of NFC technology integrated into a mobile phone is a concept to moving one or more contactless smart card into the phone, and then generates the NFC phone.

Indeed, the use of NFC mobile phones brings people to the concept of ubiquitous computing, where people no longer recognize the existence of computers in the environment.

Implementation of NFC technology in Indonesia may require longer periods of time. At least, the presence of contactless smart cards is applied in several sectors to push towards implementation of NFC technology.

In addition, the role of government is one important factor to implement NFC technology, the government through the Ministry of Communications and Information should turned away quickly in issuing ministerial decrees of implementation NFC technology.

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